Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Modification of Parts 2 and 15 of the	)	
Commission's Rules for unlicensed devices	)	ET Docket No. 03-201
and equipment approval	)	

Comments of Navini Networks, Inc

Navini Networks, Inc. ("Navini"), by its counsel, hereby submits these comments in the above-captioned proceeding. Navini is a leading manufacturer of licensed and unlicensed wireless internet access systems. Navini's RipWave 2.4 GHz system uses Part 15 spread spectrum technology to provide non-line-of-sight, high-speed access to residences, home offices and small to medium size business establishments. Using advanced digital signal processing techniques and adaptive phased array "smart" antennas, Navini base stations can simultaneously generate custom, highly directional ("beamformed") transmissions to multiple user locations. Beamforming offers significant enhancements over conventional spread spectrum transmissions by increasing the signal-to-interference and signal-to-noise ratios, thereby improving the performance of consumer premises equipment (CPE)[1] while minimizing interference to other spectrum users.

On June 13, 2002, following months of technical discussions and sample testing by the Commission staff, Navini received a grant of certification for the RipWave 2.4 GHz as a point-to-point system featuring an array of eight, 12 dBi omnidirectional antennas. Subsequently, on September 29, 2002, Navini received a Class II permissive change authorization for a similar version of this system using 8 dBi antennas. Based on these authorizations and the relevant staff interpretations of Section 15.247 which

[1] Navini CPE use omnidirectional antennas, that are purchased commercially and do not require professional installation ("zero install").

made such authorizations possible, Navini was given the informal "go-ahead" by Commission staff to proceed with its design of a flat panel (120^0) phased array using 17 dBi antennas. Certification for this system is currently pending before the Commission.

Navini is pleased that the Commission has recognized the spectral efficiencies and unique capabilities of phased array antenna technology and welcomes this rulemaking. Navini agrees that it would be beneficial to manufacturers and spectrum users for the Commission to revise and update its Part 15 rules to create regulatory certainty for this new technology.[2] Navini, therefore, takes this opportunity to comment on certain of the Commission's proposals and request clarification of others.

Summary of Navini's Position

- Navini opposes any proposal to limit the total simultaneous beamwidth of phased array antenna systems to 120^o.
- Navini opposes any limit on EIRP per beam for phased array antenna systems.
- Navini opposes any requirement to reduce power for overlapping beams in phased array antenna systems.
- Navini can support the application of Section 15.31(h) (or similar measurement procedure) to phased array antenna systems provided the aggregate power allowance is adjusted to 9dB.
- Navini supports the proposal to permit average measurements for determining output power from digital modulation devices regulated under Section 15.247.
- Navini opposes any change in the power spectral density limits for spread spectrum devices operating in the 2.4GHz band.
- Navini opposes the application of coherence to directional gain and recommends that it continue to be applied to system power.

[2] Throughout these comments, the terms "beamforming" and "phase array antenna" are used interchangeably. Both terms connote a technology, like Navini's, in which multiple directional beams can be formed simultaneously.

The Commission's Proposal to Limit Total Simultaneous Beamwidth to 120 Degrees Should not Apply to Phased Array Antenna Systems.

Until now, the Commission has approved unlicensed phased array antenna systems by interpreting its existing Part 15 rules and policies to accommodate these new technologies. Now that it has decided to develop a regulatory framework that specifically addresses phased arrays, it is important that the Commission be mindful of those systems which have been approved, or which have been developed in reliance on these past interpretations. Great care must be taken not to adopt regulations which might have the unintended consequence of negating what has recently been achieved and placed on the market. As the Notice states, "the proposed rules will accommodate the phased array antenna systems which the Commission has previously allowed by interpretation of its rules." [3] Notwithstanding the Commissons's clear intent, Navini is concerned that the proposal to apply a beamwidth limitation on both sectorized and phased array antenna systems would, if adopted, render Navini's approved systems no longer marketable. For this reason, Navini opposes the proposal as it applies to phased array antennas.

In an effort to better distinguish high power sectorized and phased array antenna systems from lower power omnidirectional antenna systems, the Commission proposes to limit the total simultaneous beamwidth radiating from an antenna structure to 120^{o}. This proposal may have merit in the case of sectorized antenna systems where several co-located transmitters, operating simultaneously, could simulate an omnidirectional system operating at the higher gain permitted only for point-to-point systems. For beamforming systems like Navini's, however, the proposal is unworkable.

Given the Commission's stated goal of accommodating "previously allowed" phased array systems, one can only surmise that the Commission believes the simultaneous beamwidth from Navini's systems do not exceed 120^{o}. In fact, however, Navini's systems are designed to transmit as many as 75 beams simultaneously, causing aggregate beamwidths frequently to exceed 120^{o}. Yet, unlike the situation with sectorized antennas, the risk of interference from a beamforming system does not increase as aggregate beamwidth expands because users share system power. As the number of

simultaneous users increase and overall power remains the same, the power per transmitted beam must decrease. Accordingly, even though collective beamwidths may exceed 120° the total area covered by the system's energy field is unchanged. The following table illustrates how the Navini system works:

	Case 1	Case 2	Case 3
Maximum Power (dBm)	30	30	30
Number of Beams (users)	2	8	12
Maximum Output Power per beam (dBm)	27	21	19
Receiver Sensitivity (dBm)	-80	-80	-80
Antenna Gain (dBi)	6.0	6.0	6.0
Maximum Path Loss Allowed per Beam (dB)	113	107	105
Coverage Radius (km)	4.4	2.2	1.8
Beamwidth of Each Beam (degrees)	30	30	30
Total Coverage Area (km^2)	10.1	10.1	10.1

As the number of beams (users) increase from 2 (Case 1) to 8 (Case 2) to 12 (Case 3), the power per beam decreases, as does the coverage radius, resulting in a total "coverage area" that remains constant.[4] Interference potential, which is a function of coverage area, also stays the same and is independent of the number of beams formed. The Commission's concern, therefore, should not be whether a system exceeds an absolute beamwidth of 120°, but whether the total system power over a given area also increases as the 120° beamwidth is exceeded. In the case of a system like Navini's, where total power and coverage are capped, there is no increased threat of interference as the collective beamwidth exceeds 120°. Indeed, if this proposal were to be adopted systems like Navini's would be unable to compete in the marketplace. Accordingly, Navini urges that a beamwidth limitation not be adopted for phased array antenna systems that are designed to share power among simultaneous users.

[3] Notice of Proposed Rulemaking ET Docket No. 03-201, par. 14, FCC-03-223, released September 17, 2003 ("Notice").

[4] Total Coverage Area = Beamwidth of each Beam x Number of Beams/ 360 x Coverage Radius^2 x □.

Imposition of an EIRP Limit on Phased Array Antenna Systems is Unnecessary.

The Commission has asked whether it should specify a maximum EIRP limit for "each individual beam."[5] For systems designed to operate at the full one watt of power permitted under the rules, the Commission is essentially asking whether a limit should be placed on antenna gain.[6] Navini submits that for phased array systems, where antenna gain is a self-limiting factor in the design and development of such equipment,[7] there is no need for EIRP limits. Should the Commission determine that some limit is necessary, however, Navini notes that Section 15.407(a)(3) of the U-NII rules limits gain from antennas used in point-to-point systems to 23 dBi. Although Navini firmly believes there should be no absolute limit on antenna gain under Section 15.247, the U-NII limit is one which has been judged reasonable by the Commission for similar devices.

No Power Reduction Should Apply in the Case of Overlapping Beams.

The Commission questions whether to require a power reduction whenever beams overlap. In the case of phased array antennas which dynamically beamform, such a requirement is not only unnecessary, but highly impractical. Navini's system uses ten 500 kHz channels which are beamformed to multiple users. Because the maximum number of simultaneous users is limited to 75, the likelihood of an overlap (i.e. same channel at the same time in the same area) tends to be small. Moreover, when an overlap does occur, there is just as great a chance the signals will cancel one another as there is a chance that they will add together. More importantly, however, the Commission should understand that the formed beams in a phased array system are not well defined energy fields and are not necessarily aligned with the user's geometrical direction. These systems dynamically analyze the multi-paths (e.g. for any changes in the environment or mobility), determine the route of least path loss, and form the beams accordingly. This

[5] It is not clear how one would determine the power, or EIRP, of a beam when dozens of beams are formed simultaneously. Proposed Section 15.247(a)(6)(iii) references "power supplied to each beam." Navini suggests that this section be revised to reference "power supplied to each transmitter."

[6] The maximum EIRP for a phased array antenna occurs only in the case of a single beam formed on a single user.

ensures the best usage of RF energy and generates the least amount of interference but does not often produce a well-characterized beam. Under such circumstances, any attempt to identify, measure and adjust for overlaps is virtually impossible. [8]

Section 15.31(h) or a Similar Procedure Should Only Apply to Adaptive Arrays if the Aggregate Power Allowance is Adjusted to 9dB.

For various reasons, the Commission has not previously applied Section 15.31(h) to Navini's technology. One reason is that Section 15.31(h) was designed only to measure emissions from Part 15 radiators whose limits were specified in terms of field strength rather than transmitter power. Because spread spectrum devices are specified in terms of transmitter output power Section 15.31(h), on its face, would not appear to be applicable to these devices. A second reason is that the purpose underlying Section 15.31(h) was to ensure that the emissions from co-located, simultaneously operating devices did not unexpectedly add or "beat" together in violation of Commission limits. In the case of phased array antenna systems, however, multiple, co-located transmitters are designed to operate in concert, to combine their emissions and produce increased gain and better signal-to-interference ratios. Any application of Section 15.31(h) to Navini's phased array systems, therefore, would have defeated the very purpose of this technology.

Proposed Section 15.247(a)(6)(iii)(B) now appears to offer of a compromise on this issue. This rule provides an allowance of 8dB of aggregate power from multiple simultaneous beams. To measure aggregate power, however, the individual transmitters (or beams) must be combined in some procedure similar to a Section 15.31(h) test. In allowing 8dB of aggregate gain, the Commission recognizes the core purpose of the phased array

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[7] As antenna gain increases so too does the size of the antenna array. At some point the array becomes too large or impractical to deploy on the types of structures which Navini base stations require.

[8] There is no way, of course, to reduce power only in an area where beams overlap without reducing power to the entire beam. In a dynamic system where beams are constantly being formed and may overlap in order to achieve paths with the least loss, a requirement to reduce power overall (assuming this could be practically implemented) would have the effect of reducing overall system coverage dramatically.

[9] Notice par. 12.

antenna system but then sets an arbitrary limit on the number of transmitters which can be combined in such array of six.[9] For an eight transmitter array like Navini's, a fair and accurate aggregation allowance would be 9dB; thus, Navini will lose 1dB of power under the proposed rule[10] as compared to existing procedures. If the Commission is truly intent on accommodating existing technology, as it says it is, Navini urges it to reconsider the allowance set forth in Section 15.247(a)(6)(iii)(B) and increase it to 9dB.

Averaging Should be Permitted for Digital Modulation Devices Operating in the Section 15.247 Spread Spectrum Bands.

The Commission notes that a digitally modulated device[11] is permitted to operate at one watt of power in the 5.7 GHz band under either the Part 15 U-NII rules or the Section 15.247 spread spectrum rules. The Commission notes also that the method for measuring power is different under each rule, with the U-NII test procedures based on average measurements and the spread spectrum procedures based on peak measurements. This difference can amount to several dB in output power. The Commission believes that the measurement procedures should be the same "regardless of the rule section under which the devices are authorized."[12] Accordingly, the Notice proposes to harmonize the test procedures by allowing average measurements to be used when certifying digital modulation devices that operate in the 915MHz, 2.4 GHz and 5.7GHz spread spectrum bands. The Commission asks for comments on this proposal and on whether there might be any "detrimental impact on the installed base of products."[13]

Navini has long advocated the harmonization of test procedures in the U-NII and spread spectrum bands and fully supports the proposed rule. In a letter filed with the

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[10]For its existing certifications, the Commission did require Navini to apply the Section 15.31(h) procedures when measuring spurious emissions. Navini had no objection to this requirement because spurious emissions are not intended to combine and their reduction or elimination will not affect the performance of the system.

[11] In the Second Report and Order, ET Docket No. 99-231, the Commission eliminated the definition of "direct sequence" and substituted "digital modulation" in its place. Digital modulation devices are required to have a 6 dB bandwidth of 500 kHz (see Section 15.247(a)(2)) and meet the ANSI C63.17 definitions (see Section 15.403).

[12] Notice par. 22.

[13] Id. par. 23.

Commission staff in November 2002, Navini pointed out this measurement anomaly and suggested that it was an oversight. Following adoption of the Second Report and Order in ET Docket No. 99-231, which authorized advanced digital modulation techniques in the Part 15 spread spectrum bands similar to those allowed for U-NII devices, Navini asked the Commission to remove this peak measurement penalty just as it had in the earlier U-NII rulemaking when it held:

> …digital modulation techniques often display symbol-to- symbol envelop variations and short duration peaks that do not cause increased interference to other operations …[and thus] … the development of high data rate modulation techniques would unjustifiably be excluded from operation in these bands without the benefit of power averaging techniques…[14]

Navini pointed out that unless the procedures were harmonized, manufacturers would be forced to implement arbitrary power restrictions (and associated design changes) on devices that use essentially the same spectrum in essentially the same way. This was not what the Commission had intended when it sought to harmonize the rules for digital modulation devices in ET Docket No. 99-231. Accordingly, Navini welcomes the proposed changes which clarify that averaging will be permitted for digital modulation spread spectrum devices operating in the Part 15 bands.

As for possible impacts on the installed base of products, Navini sees nothing detrimental from such harmonization. Digital modulation devices tested under an average measurement procedure will not cause increased interference to either licensed or unlicensed operations in the spread spectrum bands. As the Commission correctly observes, peak measurements overestimate the interference potential from "short duration spikes" and therefore, should be disregarded.[15] The use of average measurements levels the playing field for all devices by permitting them to operate at power levels that are commensurate with their interference potential. Manufacturers of other spread spectrum technologies (e.g. frequency hoppers) should not be heard to complain that such harmonization will give digital modulation devices a competitive advantage in the market

[14] See, Amendment of the Commission's Rules to Provide for the Operation of Unlicensed NII Devices in the 5GHz Frequency Range, ET Docket No. 96-102, Memorandum Opinion and Order, 12 CR 575,587 (June 17, 1998).

because, in reality, the rule proposed serves only to remove an unfair limitation that currently exists. Navini applauds the Commission for recognizing this fact and taking the necessary steps to rectify the situation.

Power Spectral Density Limits in the 2.4GHz Band Should Not be Changed.

The Commission notes that power measurement procedures are not the only difference that exist between Part 15 spread spectrum and U-NII devices; it also notes that spectrum occupancy rules are different. For devices that operate in the 5.7GHz band, Section 1.247 requires a spectral power density (SPD) of 33dBm/1MHz[16], whereas the U-NII rules for the same band require an SPD of 17dBm/1MHz. The Commission asks whether the spectrum occupancy rules should be harmonized and, if so, what those limits should be.

Navini takes no issue with SPD harmonization in the 5.7GHz band but firmly opposes any effort to apply the U-NII limits to devices operating in the 2.4GHz band. The reason these limits are different in these bands is because the bandwidths are much different. If the SPD limits were to be harmonized to 17dBm/1MHz, digital modulation devices operating in the 2.4GHz band would be required to "spread" the same amount of spectral energy over roughly 50% less bandwidth. From an EMC perspective, this would impose increased design and manufacturing costs on manufacturers with little benefit to spectrum users. Indeed, the Commission recognized this cost/benefit tradeoff in May 2002 when it considered, but rejected, the idea that the U-NII rules should be amended to include digital modulation devices operating in the 915 MHz and 2.4GHz bands.[17] In reviewing the comments filed in opposition to such harmonization, the Commission found persuasive the remarks of Intel and Silicon Wave that the use of "existing and planned equipment" would be disrupted by a lower SPD requirement and decided instead, to amend the Section 15.247 rules with the higher SPD limits.

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[15] Notice par. 21.
[16] Section 15.247(d) actually requires an SPD of 8dBm/3 kHz which equates to 33dBm/1MHz.
[17] Second Report and Order par. 15.

Navini submits that very little has changed since 2002 when the Commission last considered this issue and no new information has been placed on the record to support a reversal in policy for SPD limits in the 2.4 GHz band.[18] Accordingly, for 2.4GHz devices the SPD limits set forth in Section 15.247(d) should remain unchanged and not harmonized on the U-NII limits.

The Rules Should Allow Coherence Loss to be Applied to Power and Not as an Offset to Directional Gain.

Under the existing and proposed rules, transmitter output power must be reduced in relation to the directional gain above 6dBi.[19] For omnidirectional and point-to-multipoint systems, power must be reduced 1dB for each 1dB of directional gain above 6dBi; for point-to-point systems, the reduction is 1dB for each 3dB of gain above 6dBi. The proposed rules add a new factor to this computation by allowing directional gain to be reduced for any "coherence loss" experienced during beamforming.[20] Navini objects to this proposal because it applies coherence loss differently than applied to systems "previously allowed" by the Commission and Navini will be penalized.

When Navini's systems were approved, coherence loss was applied as a power offset to the reduction that would otherwise be required for antenna gain exceeding 6dBi. In other words, system antenna gain was first determined; then a "1 for 3" reduction in power was calculated under the point-to-point rule; and, from this figure coherence loss was subtracted to arrive at the amount by which the transmitter power had to be reduced. In this manner, coherence loss was fully restored on "dB for dB" basis. The proposed rule, however, changes this procedure significantly by offsetting coherence loss against antenna gain. This will result in 33% less of an power adjustment for coherence loss than permitted for current products. The Notice provides no technical justification for this

[18] The Commission said that the U-NII rules had been adopted after exhaustive rulemaking and detailed studies on these issues (e.g. SPD), and that it has not had "an opportunity to examine similar information" for the spread spectrum bands.
[19] See proposed Section 15.247(a)(6)(iii).
[20] See proposed Section 15.247(a)(6)(iv)(B).

sudden change in policy and therfore, it should not be implemented. Instead, Navini urges to the Commission to maintain consistentcy with its previous approach and allow coherence loss to be applied after any directional gain power reduction is determined.

Conclusion

By proposing to adopt regulations specific to unlicensed phased array antenna systems, the Commission has taken a significant step toward promoting new technology and fostering local broadband competition. Navini believes that, for the most part, the Commission's proposals are reasonable and should provide a solid regulatory framework for the future. Navini is concerned, however, that certain proposals will sidetrack the Commission from its stated goal to "accommodate the phased array antenna systems … previously allowed by … the rules." In particular, the proposed 120^{o} aggregate beamwidth limitation, while reasonable for sectorized antennas, simply cannot be met by phased array antenna systems like Navini's which transmit simultaneous beams to multiple users. Because such systems share power over fixed areas of coverage, they should not be saddled with an arbitrary limit on aggregate beamwidth. Moreover, because beams in a multi-path "rich" environment are extremely difficult to characterize, the Commission should abandon any notions of a power reduction for overlaps and EIRP limits per beam. Navini also recommends substantive changes in the proposed rules to provide an aggregate transmitter power allowance of 9dB, rather than 8dB, and to apply the "coherence loss" offset to power, rather than the directional gain of a system. Finally, Navini strongly supports the use of average measurements rather than peak for digital modulation devices.

Respectfully Submitted,

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